LUNG CANCER AFTER EMPLOYMENT IN SHIPYARDS DURING WORLD WAR II

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Abstract A case-control study, undertaken to identify reasons for the exceptionally high rate of lung cancer among male residents of coastal Georgia, revealed a significantly increased risk associated with employment in area shipyards during World War II. The summary relative-risk estimate, adjusted for smoking, other occupations, age, race and county of residence was 1.6 (95 per cent confidence limits = 1.1 to 2.3). A synergistic relation was found between shipyard employment and cigarette smoking. These findings suggest that asbestos and possibly other shipyard exposures during wartime employment account for part of the excess mortality from lung cancer in certain coastal areas of the United States. (N Engl J Med 299:620-624, 1978)

THE mapping of cancer mortality in the United States according to county, 1950-69, revealed an area along the southeast Atlantic coast where the rates for lung cancer were exceptionally high among white men.[1,2] To identify reasons for the elevated mortality, we conducted a case-control study of lung cancer diagnosed among residents of coastal Georgia.

METHODS

Cases of primary lung cancer among male residents of an 11-county coastal area* were identified from three sources: diagnoses since 1970 at the single large hospital in Brunswick; diagnoses during 1975-76 at the three major hospitals in Savannah; and death certificates for the period 1970-74 among residents of Chatham (Savannah) and the neighboring rural coastal counties where death was attributed to lung cancer (eighth revision of *International Classification of Diseases* 162.1).

Controls were selected from admissions to the four hospitals and from death certificates for diagnoses other than lung cancer, bladder cancer or chronic lung disease. The hospital controls were nearest admissions at the same facilities of similar sex, race, age (±2 years), county of residence and current vital status. Two controls were chosen for each case in Brunswick (where the number of cases was smaller), and one for each case in Savannah. A single death-certificate control was selected for lung-cancer cases identified by death certificate according to similar matching criteria.

Personal interviews of the patients and controls, or their next of kin in the event that they had died, were conducted by locally hired public-health nurses and interviewers under the supervision of a professional survey organization. Each interviewer was trained in interviewing technics, including standardized methods of probing. Nearly all questions were in closed form to minimize inter-observer biases. Sample questions in 10 per cent of all interviews were later checked for verification by telephone.

Information was obtained on place, type and length of employment for all jobs held for six months or more. The respondents were asked to describe the duties performed for each job, as well as to list materials handled during the course of their work. The occupational section of each questionnaire was concluded by review with each respondent of a checklist of industries (including shipbuilding) and materials (including asbestos). Data obtained on cigarette-smoking characteristics for each respondent included, for those who had at some time smoked — "ever smokers" —: the age they started, usual amount smoked, age (or ages) when they had stopped smoking and type of cigarette.

Estimates of the relative risk (odds ratios) of "ever" (six months or more) employment upon lung cancer were calculated for each of 16 industrial categories, including shipbuilding.[3] The relative-risk estimates were determined for various strata categorized according to race (white or black), age at diagnosis or death (30-54, 55-64 and 65+), county of residence (Chatham, Glynn and other), "usual" industry of employment (16 categories) and cigarette smoking (three categories). We calculated tests for interactions of the relative risks for shipbuilding across the various levels of the other factors, using a logistic representation of these retrospective data.[4] When effect modification was absent, summary relative risks were estimated and tested by this technic,[4] as well as by the Mantel-Haenszel method.[5]

To obtain an estimate of the possible effect of inaccuracies of next-of-kin responses, we conducted simultaneous interviews, usually of the husband and wife, for a small sample (24 pairs) of the study subjects and their next of kin.

RESULTS

A total of 535 cases of primary lung cancer and 659 controls were identified from the Brunswick and Savannah hospitals and the Chatham and rural-county mortality series (Table 1). This distinction excludes 23 Savannah hospital cases in residents of smaller coastal counties, since appropriate hospital controls matched for county of residence for the group could not be easily obtained.

Interviews were completed for 89 per cent of the lung-cancer cases and 87 per cent of the controls. Of those not interviewed, about two thirds had moved out of the coastal area or could not be located; for the remainder, either the patient or next of kin (32 cases) or attending physician (14 cases) would not consent to interview. Approximately 4 per cent of the subjects interviewed had lived in coastal Georgia for less than five years and were excluded from the analysis. Thus, the study group consisted of 458 lung-cancer cases and 553 controls, most of whom were longtime residents (median of 41 years) of coastal Georgia.

The major findings of this study pertained to shipyard employment. Shipbuilding was the "usual" industry in eight cases (mostly workers in smaller shipyards) and one control (crude relative risk of 9.8). However, 95 patients and 80 controls (crude relative risk of 1.5) were employed at some time in the industry, most working for just a few years during World War II (only 21 per cent of the total worked in the in-

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*Included were Brantley, Bryan, Camden, Charlton, Chatham, Glynn, Liberty, Long, McIntosh, Pierce and Wayne counties. The participating hospitals were Glynn-Brunswick Memorial Hospital, Candler General Hospital, St. Joseph's Hospital and Memorial Medical Center.

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dustry for more than five years). As shown in Table 2, the risk ratios were greater than 1 regardless of the method of ascertainment for the series comprising this investigation.

The higher risk associated with shipbuilding was not accounted for by cigarette smoking. Table 3 shows elevated relative risks for shipbuilding in each of three cigarette-smoking categories. The first smoking category consisted of those who had never smoked, those who usually smoked less than half a package per day (whose risk relative to that of never smokers was 0.4) and workers who had stopped smoking at least 10 years before diagnosis (risk of 1.8); the second group included smokers who usually smoked half a package to 1½ packages per day (risk of 4.5), in addition to those (13 per cent of the total) whose usual amount smoked was unknown (risk of 6.2); and third, those who usually smoked two or more packages per day (risk of 8.6). The summary relative risk for shipbuilding, adjusted for cigarette smoking by the Mantel–Haenszel method, was 1.6 (P = 0.006).

Table 1. Numbers of Lung-Cancer Cases and Controls Identified for Study by Method of Ascertainment.

Source of Identification	Period	Cases	Controls
Brunswick Hospital	1970-76	170	319
Savannah hospitals	1975-76	149	153
Death certificate	1970-74	216	187
Totals		535	659

The higher estimates of relative risk for shipbuilding were seen in both whites and blacks, in all age categories and in Glynn (Brunswick), Chatham (Savannah) and the rural coastal counties as well (Table 4). The higher risks for shipbuilding were also not readily explicable by other occupations. Table 5 shows that the distribution of the "usual" industries of employment of those who had worked in shipyards included a higher proportion of construction and farming jobs and a lower proportion in the paper and pulp industry than the distribution among those who had never worked in the shipbuilding industry. The relative risks for farming and the paper industry, adjusted for smoking, were 0.7 and 1.0, so that the differential representation in these two industries does not account for the increase associated with shipbuilding. There was a smoking-adjusted increased risk of 1.3 associated with construction, but the risk with shipbuilding was high among both construction and nonconstruction workers (Table 6).

When smoking, residence, age, race and usual industry were simultaneously taken into account in the logistic model, the adjusted summary relative risk was 1.6 (P = 0.01), with 95 per cent confidence limits of 1.1 to 2.3. Although the relative risks for shipbuilding increased with heavier consumption of tobacco, the differences in these risks among the three smoking categories were not statistically significant (P>0.10).

Table 2. Relative Risks for Shipbuilding According to Method of Ascertainment and County of Residence, Cases and Controls.

Series	County of Residence	Case or Control	Ever Employed in Shipbuilding: Yes	Ever Employed in Shipbuilding: No	Relative Risk
Brunswick Hospital	Glynn	Case	19	62	1.7
		Control	23	130	
	Other rural	Case	10	45	1.3
		Control	18	101	
Savannah Hospital	Chatham	Case	23	111	1.4
		Control	17	116	
Mortality	Chatham	Case	32	91	2.0
		Control	14	79	
	Other rural	Case	11	54	1.2
		Control	8	47	

Nevertheless, the excess risk increased sharply with smoking (Fig. 1), indicative of a strong synergism between these two risk factors.

Table 7 shows relative-risk estimates according to types of shipyard jobs. An excess risk was not seen for welders or riggers, but was apparent for other groups, including those where direct exposure to asbestos would not be likely. Each interview requested information on whether asbestos was among the "materials handled at work." Among the 175 respondents in our study who had worked in shipbuilding, contact with asbestos was reported by only 10 (four cases and six controls).

Information obtained on the specific histologic types of primary lung cancer among the hospital series revealed no differences among those ever employed in the shipbuilding industry as compared to those never so employed.

The small sample evaluation of comparability of patient and next-of-kin responses revealed little difference in "usual" occupation according to type of respondent. The patients, however, tended to report a greater number of jobs ever-held (particularly in farming, although not in shipbuilding) than their next

Table 3. Relative Risks for Shipbuilding According to Cigarette-Smoking Category.

Smoking Category*	Case or Control	Ever Employed in Shipbuilding: Yes	Ever Employed in Shipbuilding: No	Crude Relative Risk
Nonsmoker, light smoker or stopped smoking	Case	11	50	1.3
	Control	35	203	
Moderate	Case	70	217	1.7
	Control	42	220	
Heavy	Case	14	96	2.4
	Control	3	50	

*See text for definition of categories.

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of kin. Concordance for smoking category was 83 per cent, with the discrepancies split between higher and lower consumption reported by the next of kin, in each instance with the classification by the study subject and next of kin being in adjacent categories. Most (76 per cent) of the interviews for the entire sample of 458 cases and 553 controls were with next of kin. When the total data were stratified according to type of respondent, the risk ratios for shipbuilding were 1.5 for self-respondents and 1.6 for the next-of-kin respondents.

Discussion

Because of excellent community participation (less than 3 per cent of those approached refused interview), it was possible to cover nearly all the identified subjects in this case-control investigation. However, since lung cancer is often rapidly fatal — nationally the median survival is five months[6] — most of the interviews were conducted with the next of kin of deceased persons. Our sample check for comparability revealed generally good agreement between self and next-of-kin responses, but some inaccuracies may have resulted from second-party reporting, or from the difficulties in recalling events taking place 30 or more years before the interview. However, these possibilities seem unlikely to have produced any major differences between cases and controls.

A significantly higher risk of lung cancer was found in Georgia residents who worked in shipyards during World War II. The higher risk, which was observed in each of five independent series of lung-cancer cases and controls in this investigation, was not readily explicable by smoking habits or other occupational exposure. The excess was seen in white and black men in both Savannah and Brunswick, where two large shipyards began operations in 1942. By late 1943 about 22,000 were employed in the Savannah shipyard, and about 16,000 in Brunswick.[7,8] Both yards closed shortly after the war's end. Twenty-one per cent of the patients with lung cancer in our study reported working in the industry. Among the small number of men who continued to work in shipbuilding and repair at other locations, the risk of lung cancer was exceptionally high. It seems likely, therefore, that shipyard exposures account for at least part of the excess mortality from lung cancer in coastal Georgia. Assuming that 14 per cent (the proportion among controls) of the general population in the area had worked in the shipyards and were at 1.6 times the "usual" risk of lung cancer, and assuming that the remaining 86 per cent were at usual risk, the coastal lung-cancer rate would be expected to exceed the usual rate by about 8 per cent. Provisional estimates of mortality rates from lung cancer for 1970-75 among white men show that the rates in the area

Table 4. Relative Risks for Shipbuilding According to Race, Age and Residence.

Indicator	Case or Control	Ever Employed in Shipbuilding		Crude Relative Risk	Smoking-Adjusted Relative Risk
		Yes	No		
Race:					
White	Case	82	315	1.5	1.5
	Control	67	381		
Black	Case	13	48	1.9	2.0
	Control	13	92		
Age (yr):					
<55	Case	13	73	1.8	1.8
	Control	10	102		
55–64	Case	34	124	1.4	1.5
	Control	29	150		
65+	Case	48	166	1.6	1.6
	Control	41	221		
Residence:					
Chatham	Case	55	202	1.7	1.6
	Control	31	195		
Glynn	Case	19	62	1.7	2.1
	Control	23	130		
Other	Case	21	99	1.2	1.5
	Control	26	148		

Table 5. Percentage Distribution of Usual Industry of Employment among Those Ever Employed in Shipbuilding as Compared to Those Never Employed in This Industry.

Usual Industry	Ever Employed in Shipbuilding	
	Yes	No
Agriculture	14.3	9.2
Fishing	0	2.2
Forestry	1.1	1.8
Construction	16.6	8.4
Lumber-wood	2.3	4.4
Metal-machinery	2.9	2.8
Shipbuilding	5.1	0
Paper-pulp	1.7	7.8
Chemicals or other nondurable-goods manufacture	2.9	5.5
Transportation	18.3	15.7
Wholesale & retail	9.1	11.7
Personal service	4.0	2.9
Professional & government	8.6	11.1
Military	0.6	3.3
Not elsewhere classified	4.6	5.3
Unknown	8.0	8.0
Totals	100.1	100.1

Table 6. Relative Risks for Ever Employment in the Shipbuilding Industry According to Usual Employment in the Construction Industry.

Usual Industry Construction	Case or Control	Ever Employed in Shipbuilding		Crude Relative Risk	Smoking-Adjusted Relative Risk
		Yes	No		
No	Case	77	331	1.5	1.6
	Control	69	435		
Yes	Case	18	32	1.9	2.0
	Control	11	38		

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exceed the national rate by about 30 per cent, suggesting that the coastal excess may be only partly attributable to wartime shipyard exposures. However, it is possible that the maximum effect of exposures during World War II occurred before the 1970-76 period of investigation, so that the risks presented in this study may be underestimates.

Ship construction and repair involves contact with asbestos,[9,10] which is known to induce lung cancer and mesothelioma, but few data on this exposure are available from our survey. Only 5 per cent of those ever employed in the shipyards reported handling asbestos during shipyard duties, with only one classified as an insulator. The lung-cancer risk did not seem limited to any particular shipyard trade, in agreement with reports from Europe of mesothelioma among

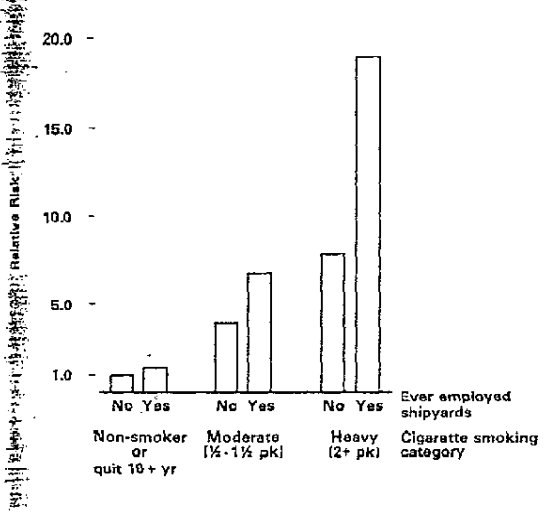

Figure 1. Relative Risk of Lung Cancer According to Usual Cigarette-Smoking Category and Employment in Shipyards during World War II.

various classes of shipyard workers.[10-16] Asbestos-related lung disease has been seen in pipecoverers in shipyards in the United States[17] and also among other workers regardless of their occupation within the industry.[18] Furthermore, the multiplicative effect between shipyard employment and cigarette smoking in our study is consistent with other reports of a synergism between exposure to asbestos and smoking on lung-cancer risk.[19]

Despite the increased mortality from lung cancer in coastal Georgia, we found only five cases with mesothelioma and two with asbestosis through a search of medical records and pathology files since 1960 in the participating hospitals. This number of cases of mesothelioma was not higher than the national incidence estimated at about two cases per million per year,[20] but diagnostic ascertainment in the area may be incomplete. On the other hand, since mesotheliomas have been reported to occur even after relatively light exposures to asbestos,[21,22] the failure to see greater numbers of this rare tumor among coastal residents raises the possibility of shipyard hazards in addition to asbestos.

Table 7. Relative Risks for Ever Employment in Major Shipbuilding Job Subcategories.

Subcategory	Cases*	Controls*	Crude Relative Risk
Insulator, boiler maker	2	2	1.2
Pipefitter	10	4	3.1
Shipfitter, steamfitter	6	5	1.5
Welder, burner	11	20	0.7
Rigger, leaderman	6	9	0.8
Machinist, machine operator, metal worker	13	11	1.4
Laborer, construction	24	20	1.5
Electrician	5	3	2.0
Clerk, accountant, draftsman, guard	7	3	2.8
Not specified	15	5	3.7

*Total no. slightly exceeds no. ever employed in the shipbuilding industry since persons with jobs in >2 categories were counted in each.

Further studies of shipyard workers should help quantify the risk of lung cancer, mesothelioma and other tumors seen after exposure to asbestos.[23] The magnitude of the problem may be greater than has previously been thought, since counties throughout the United States with wartime shipyards tend to have elevated mortality not only from lung cancer but also from cancers of the larynx, oropharynx and upper gastrointestinal tract.[24]

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EFFICACY OF CHEST PHYSIOTHERAPY AND INTERMITTENT POSITIVE-PRESSURE BREATHING IN THE RESOLUTION OF PNEUMONIA

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Abstract We undertook a randomized clinical trial to evaluate the efficacy of chest physiotherapy and intermittent positive-pressure breathing in the treatment of pneumonia. The diagnosis of pneumonia required a compatible clinical history and x-ray confirmation. A total of 54 patients were assigned to treatment and control groups and were similar in age, smoking history, underlying lung disease and prior antibiotic treatment. Antibiotic therapy, guided by Gram stain and sputum and blood cultures, was similar in both groups. Chest physiotherapy, consisting of postural drainage, percussion and vibration, was given concurrently with intermittent positive-pressure breathing with use of racemic epinephrine every four hours. There was no statistically significant difference in duration of fever, extent of radiographic clearing, duration of hospital stay and mortality between the control and treated groups. Chest physiotherapy and intermittent positive-pressure breathing do not hasten the resolution of pneumonia. (N Engl J Med 299:624-627, 1978)

A RECENT symposium[1] held under the auspices of the American Thoracic Society evaluated the scientific basis of respiratory therapy, including chest physiotherapy and intermittent positive-pressure breathing. These therapies, now extensively used in diverse bronchopulmonary disorders, have not often been validated by randomized clinical studies, or such studies have failed to show clinical benefit.[2-5] One application not previously studied is their efficacy in the treatment of pneumonia. Despite the lack of data concerning effectiveness in this common clinical situation, an in-house retrospective study of 100 consecutive patients hospitalized at the Medical Center Hospital of Vermont with pneumonia revealed that chest physiotherapy and intermittent positive-pressure breathing were used as therapeutic adjuncts in two thirds of the cases. Furthermore, a survey carried out on the treatment of pneumonia in four regional hospitals in Vermont showed that as many as 64 per cent of patients received intermittent positive-pressure breathing, and 44 per cent received chest physiotherapy — a frequency of use estimated to occur nationwide (Baker JP: personal communication). To assess the effects of this form of therapy in hastening the resolution of pneumonia, we conducted a randomized prospective clinical trial.

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METHODS

Patients admitted to a pulmonary unit with a radiographic diagnosis of pneumonia and a compatible clinical history of fever and increased cough were eligible for randomization. Informed consent was required. Patients were excluded from the study by any of the following complicating factors: lung abscess, established underlying bronchiectasis, tuberculous pneumonia or cystic fibrosis; respiratory failure (partial pressure of carbon dioxide over 50 mm Hg), or a need for assisted ventilation; presence of renal failure (blood urea nitrogen over 40 mg per deciliter); immunosuppressive therapy (receiving more than 40 mg per day or equivalent of prednisone, azathioprine or antineoplastic agents); strokes within six weeks; and underlying cancers.

Patients with other underlying cardiopulmonary disorders, such as heart disease or chronic obstructive lung disease were included, as were those with medical conditions such as alcoholism and diabetes. Postoperative patients were not studied.

The randomization procedure pre-stratified patients on the basis of age (under or over 55 years), smoking history (smoker vs. nonsmoker), sex and prior antibiotic therapy. The house officer looking after the patient then selected a pre-randomized sealed envelope containing a control or treatment group label, which assigned the patient.

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